Computer assisted early diagnosis of diabetic retinopathy using machine learning

SHORT SYNOPSIS

Submitted in partial fulfillment of the requirement of the degree of

DOCTOR OF PHILOSOPHY

to

Manav Rachna University

by

Anju Mishra
Registration number:
2K20-PFE-004

Under the supervision of

Dr. Mrinal Pandey
Associate Professor

Department of Computer Science and Technology
Faculty of Engineering

MANAV RACHNA
vidyanatariksha
MANAV RACHNA UNIVERSITY
(FORMERLY MANAV RACHNA COLLEGE OF ENGINEERING
NAAC ACCREDITED 'A' GRADE INSTITUTION)
Declared as State Private University under section 2f of the UGC act, 1956

2019-2020

MANAV RACHNA
vidyanatarikshah

MANAV RACHNA UNIVERSITY
(FORMERLY MANAV RACHNA COLLEGE OF ENGINEERING
NAAC ACCREDITED 'A' GRADE INSTITUTION)
Declared as State Private University under section 2f of the UGC act, 1956

DECLARATION BY THE SCHOLAR

I hereby declare that the short synopsis "**Computer assisted early diagnosis of diabetic retinopathy using machine learning**" being submitted in partial fulfillment of the requirement for the Degree of Doctor of Philosophy in Department of Computer Science and Technology under Faculty of Engineering of Manav Rachna University, Faridabad during the academic year 2019-2020 Even.

It is a bona-fide record of original work carried out under the supervision of Dr. Mrinal Pandey and Dr. Laxman Singh has not been submitted in full or part to any other university or institute for degree or diploma. Further, it is certified that short synopsis is within the plagiarism limit and copy of the same is attached as per University norms.

(Anju Mishra)
2K20-PFE-004

14/1/2021

Signature of the Supervisor
Dr. Mrinal Pandey, Associate Professor and
Faculty of Engineering, MRU

Signature of the Co-Supervisor,
Dr. Laxman Singh, Associate
Professor and Department of
Electronics and Communication,
NIET, Greater Noida

Susmita Ray
19/1/2021

Chairman, DRC

MANAV RACHNA UNIVERSITY

Established, vide Haryana Act no. 26 of 2014
(Formerly Manav Rachna College of Engineering,
NAAC Accredited 'A' Grade Institute)

Ref No. MRU/DRC/2020-21/CST **Dated: 15/12/2020**

Notification

It is to notified that ~~Mr/~~Ms. Anju Mishra……Enrollment No 2K20-PFE-004 presented Research Proposal before DRC/~~SRC~~ on Broad Area…Machine Learning …… Proposed Research Topic…. Computer assisted early diagnosis of diabetic retinopathy using Machine Learning... on dated…15/12/2020… The scholar is working under the supervision of Dr. Mrinal Pandey… (Supervisor) and Dr.Laxaman Singh ……(Co-Supervisor).

The recommendations of DRC/~~SRC~~ on proposed research work are:

1. Approved with No changes ☐
2. Approved with Minor changes ☐ √
3. Approved with Major changes ☐
4. Not Approved ☐

The suggestions for changes are:

1. Two separate areas have been mentioned in Research Objectives
2. Need to think about Research Objectives carefully and modify appropriately
3. Proceed for Short Synopsis submission after incorporating the above mentioned review comments from DRC

Susmita Ray

Dr. Susmita Ray
DRC Chairperson

Prof. Dr. Anjana Gosain
External Expert

Jyoti

Dr. Jyoti Pruthi
DRC Member

Hardeo

Dr. Hardeo Kumar Thakur
DRC Member

ABSTRACT

Diabetic Retinopathy (DR) is a disease in human eye caused due to the damage in retina, may lead to sightlessness. Early diagnosis of the diabetic retinopathy disease may save the vision and can avoid complete blindness. The detection process may include physical test like visual acuity test, pupil dilation, optical coherence tomography but are time consuming and affects patients as well. This study reviews the latest techniques of digital image processing (DIP) and pattern classification used for diagnosis of DR and compare them based on various criteria like accuracy, disease state, sensitivity. Primarily DR has two major levels, Non-Proliferative Diabetic Retinopathy (NPDR) and Proliferative Diabetic Retinopathy (PDR). Further DR has subdivisions of states. This paper reviews the literature of all analyzed domain.

Key words: Fundus Images, Proliferative Diabetic Retinopathy, Non-proliferative diabetic retinopathy

CONTENTS

S. No.	Description	Page No.
1	Introduction	1-6
2	Literature Review	6-8
3	Objectives of the Study	8
4	Methodology to be adopted	8-9
5	Expected Outcome of the Research	9
6	Research Gap	9-10
7	References	10-11

1. Introduction

Diabetes is one of the major issues confronted by world, which is the driving cause of diabetic retinopathy. Around 415 million diabetic patients are at hazard of having visual impairment due to diabetes. It harms the blood vessels in the interior the retina (the light delicate layer at the rear side of the eye). This small blood vessel will spill blood and liquid on the retina shapes highlights such as micro-aneurysms (MA), hemorrhages (HE), difficult exudates, cotton wool spots or venous loops. Hence, visual impedance due to diabetic retinopathy remains a substantial health burden. DR categorized as non-proliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR). The stages of DR can be distinguished based on presence of features on the retina.

There are 5 significant level of clinical DR severity.

- The earliest clinically evident phase of DR is minor NPDR, illustrated as the growth of microaneurysms.
- The illness will reach to moderate NPDR where extra lesions created, as well as venous caliber changes and intraretinal microvascular anomalies.
- The severity and intensity of these lesions is enhanced in severe NPDR, and retinal blood supply gets to be gradually negotiated. Therefore, the non-perfused zones of the retina impart signs accelerating new blood vessel growth, driving to PDR. The new blood vessels are anomalous, friable, and can bleed simply usually causing extreme visual damage.
- Diabetic macular edema (DME) happens once there is inflammation in the retina due to spilling of fluid from blood vessels inside the macula, and can occur throughout any stage of DR.
- The DR can be recognized and treated at a very early stage, as the movement from no retinopathy to PDR with the slow rate and may take 2 decades or more, which will give a period to control diabetes. Diabetes is the leading cause of DR.

The early indications of DR; that microaneurysms, hemorrhages, and exudates are appearing on the surface of the retina. Initially DR is consistently asymptomatic, but amiable to treatment. The DR study and therefore the Early Treatment of Diabetic Retinopathy Study (ETDRS), indicated

the treatment with laser photocoagulation can more than decrease the chance of creating visual loss from PDR

2. Literature Review

There are numerous techniques of machine learning that has been used for detecting the DR in the early stage by several researchers. Here we have reviewed the work of several authors related to DR.

(Bhaskaranand M., et. al.,2016) designed a screening tool to provide a "refer" or "no refer" or "borderline refer" of "confident refer" with accuracy, depending on the decision statistics different ranges of sensitivity and specificity thresholds [1].

(Gulshan V., et. al.,2016) developed an algorithm using convolution neural network, which produces a consistent number somewhere in the range of 0 and 1 for referable DR and other DR categories, relating to the probability of that condition be seen in the image [2].

(Carson Lam, et. al., 2018) introduces an automatic DR grading system efficient to categorizing images based on disease pathologies from five severity levels. GPU Training System (DIGITS) is used to build a classification dataset [3].

(Gupta S., Karandikar AM, 2015) convert fundus images into HSI i.e. hue saturation and intensity model. Hybrid median filter is then applied to remove noise. After pre-processing, feature extraction and classification has been done. All the calculated features are then applied to SVM and KNN classifier for comparative study on given dataset [4].

(Sheikh Muhammad Saiful Islam, et. al., 2018) proposed 18-layer deep network architecture for early-stage detection and severity grading model. In this paper two binary classification for early-stage detection used and, the state-of-the-art performance metric for multiclass classification as the performance metric of severity grading prediction of DR [5].

(Bhatia K., et. al.,2016) proposed that SVM Classifiers used to build an automated system to distinguish the case of DR among the diabetic patients [7].

(Cao W., et. al., 2018) uses SVM, RF and NN methods of machine learning conducted the work

on DIARTEDB1 and ROC database and measured by both AUC and F-measure. The result is a promising step towards automatic early detection of microaneurysms and DR [10].

(Gurudath N., et. al.,2014) uses ANN and SVM methods to automate the identification of the presence of DR from color fundus images of database DRIVE and DIARETB1. The Experimental results increase the sensitivity and accuracy on both the methods than already well-established results [11].

(Gargeya R., et. al.,2017) evaluate the precision–recall trade-off of proposed algorithm, using (AUC) as a metric and calculate 94% sensitivity and 98% specificity with the 0.97 AUC on local data set. When tested on the MESSIDOR 2 and E-Ophtha databases, it achieved 0.94 and 0.95 AUC scores, respectively [12].

(Khojasteh P., et. al.,2019) uses CNNs, Pre-Trained Residual Networks with the classifiers, DRBM-based model techniques. The result shows “Resnet-50 + SVM” model worked the best for e-Ophtha database and for DIARETDB1 database [13].

(Lin, Gen-Min et al.,2018) initially grade the DR level from 0-4 grading scale and converts the original images into entropy images. Then achieve the increased accuracy of 86.10%, Sensitivity 73.24%, and Specificity 93.81% on entropy images over original images using CNN [14].

(García G., et. al.,2017) propose a CNN approach and achieves 93.65% specificity and 83.68% accuracy was achieved but only 54.47% in sensitivity on the dataset of 80,000 images [17].

(S K, S., 2017) uses ML-BEC method, voting classification performed for the final prediction thus reducing the classification time and effectively improving the classification accuracy. BEC is employed to minimize the error during automatic detection of DR [18].

(Hemanth, D.J., et., al.,2020) proposes a hybrid solution method, include both DIP and deep learning. Histogram equalization (HE) and the differentiate constrained adaptive histogram equalization (CLAHE) both are used for DIP, to prepare the retinal fundus images better for classification by a convolutional neural network (CNN), for diagnosis. The accuracy sensitivity,

specificity, precision, FScore and the GMean was 97%, 94%, 98%, 94%, 94% and 95% achieved respectively [19].

3. Objectives of the Study

The aim of the study is to create a computer aided diagnosis system for the early recognition of diabetic retinopathy using Machine Learning procedures. The objective(s) of proposed study are as follows:

1. To do extensive literature Review.
2. To implement preprocessing and image segmentation algorithms for image enhancement and identification /detection of diabetic retinopathy.
3. To develop a robust computer aided diagnosis system using machine learning/deep learning algorithm that would be able to deal with the different types of retinopathy images to the same degree of effectiveness without bias.

4. Methodology to be adopted

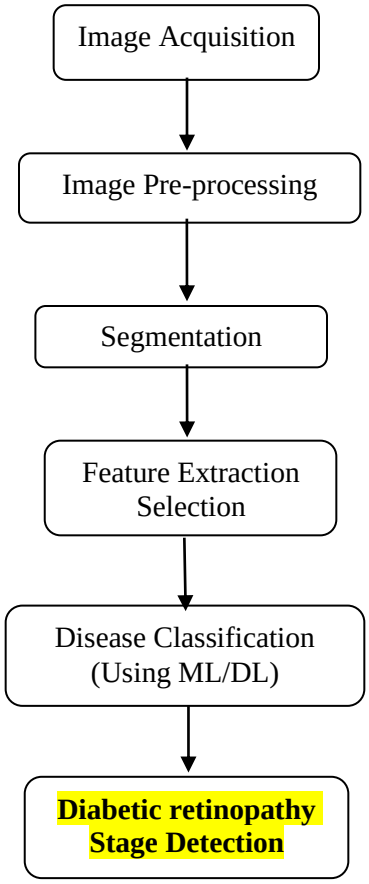
In this research, the process is divided in phases:

a. We gather the data from private hospitals.
b. Then we pre-process the data or clean the data using digital image processing techniques.
c. Thereafter, we shall apply segmentation technique to segment the object of interest.
d. After that, we will use an appropriate machine learning technique, that shall be used to develop a classifier. We will use geometrical, morphological & texture features as an input to the classifier.

These will be extracted from vessels, dark lesions, bright lesions, exudates, and other reddish object (Regions of Interest - ROIs) based on the morphological, and texture in digital funds photographs.

e. Then with the support of training data, we can count the number of different round shapes in fundus images.

Later, I will use deep learning technique to get the better result for saving the vision of patients.



5. Expected Outcome

Proposed approach based on image processing segmentation algorithms will extract retinal exudates, blood vessels, micro-aneurysms, and other reddish objects (Regions of Interest - ROIs) even from a low-quality retina image.

Development of a robust computer aided diagnosis system using ML/DL. The developed system will assist the ophthalmologist and help them to identifies and grades the severity of diabetic retinopathy.

6. Research gap

While going through literature, it has been observed that

- There is no such technique available which could be used commercially, irrespective of variability in data set (Applicable to all kind of datasets).
- The latest techniques in deep learning models are yet to be explored (therefore, we will try to implement /use the emerging architecture which has not been used till date for early

diagnosis of diabetic retinopathy in our study).

- Using these latest techniques, we will try to develop computer assisted diabetic retinopathy diagnosis system.

7. References

1. Malavika Bhaskaranand, Sandeep Bhat, Srinivas Sadda, **"Automated diabetic retinopathy screening and monitoring using retinal fundus image analysis"**. In J Diabetes Sci Technol. vol.10, pp.254–61. Year 2017.
2. Varun Gulshan, Subhashini Venugopalan, Rajiv Raman **"Development and validation of a deep learning algorithm for detection of diabetic retinopathy in retinal fundus photographs"**, In JAMA. Vol. 316, pp:2402–10, Year 2016.
3. Carson Lam, Darvin Yi, Margaret Guo, Tony Lindsey **"Automated Detection of Diabetic Retinopathy using Deep Learning"**, in Proceedings of AMIA Joint Summits of Translational Science 2017, pp.147-155, Year 2018.
4. Swati Gupta and AM Karandikar, "**Diagnosis of Diabetic Retinopathy using Machine Learning"**, in Journal of Research and Development, Vol.3, No.2, pp.127-132, Year 2015.
5. Sheikh Muhammad Saiful Islam, Md Mahedi Hasan, Sohaib Abdullah, **"Deep Learning based Early Detection and Grading of Diabetic Retinopathy Using Retinal Fundus Images", in** Computer Vision and Pattern Recognition, Vol. abs/1812.10595, pp.1-12, Year 2018.
6. Tao Li, Yingqi Gao, Kai Wang, Song Guo, Hanruo Liu, Hong Kang, **"Diagnostic assessment of deep learning algorithms for diabetic retinopathy screening",** in Elsevier 2019.
7. Bhatia K., Arora S., & Tomar R, **"Diagnosis of diabetic retinopathy using machine learning classification algorithm"**, in IEEE 2016 2nd International Conference on Next Generation Computing Technologies (NGCT).
8. Wei Zhang, Jie Zhong, Shijun Yang, Zhentao Gao, JunjieHu, Yuanyuan Chen, Zhang Yi, **"Automated identification and grading system of diabetic retinopathy using deep neural networks"**, in Elsevier 2019
9. Rakhlin Alexander**, " Diabetic Retinopathy detection through integration of Deep Learning classification framework",** in bioRxiv.
10. W. Cao, N. Czarnek, J. Shan and L. Li, **"Microaneurysm Detection Using Principal Component Analysis and Machine Learning Methods,"** in IEEE Transactions on Nano Bioscience, vol. 17, no. 3, pp. 191-198, July 2018.
11. N. Gurudath, M. Celenk and H. B. Riley**, "Machine learning identification of diabetic retinopathy from fundus images,"** 2014 IEEE Signal Processing in Medicine and Biology Symposium (SPMB), Philadelphia, PA, 2014, pp. 1-7.
12. Rishab Gargeya, Theodore Leng, **"Automated Identification of Diabetic Retinopathy Using Deep Learning"** 2017 American Academy of opthomology, ISSN: 1549-4713, Vol: 124, Issue: 7, Page: 962-969

13. Parham Khojasteh, Leandro Aparecido Passos Ju´nior, Tiago Carvalho, Edmar Rezende, Behzad Aliahmad, Jo˜ao Paulo Papa, Dinesh Kant Kumar **"Exudate Detection in Fundus Images Using Deeply-learnable Features"** 2019 Computers in Biology and Medicine, Elsevier Volume 104, January 2019, Pages 62-69
14. Lin, Gen-Min, Mei-Juan Chen, Chia-Hung Yeh, Yu-Yang Lin, Heng-Yu Kuo, Min-Hui Lin, Ming-Chin Chen, Shinfeng D. Lin, Ying Gao, Anran Ran and Carol Yim-lui Cheung**. "Transforming Retinal Photographs to Entropy Images in Deep Learning to Improve Automated Detection for Diabetic Retinopathy."** Hindawi, Journal of Ophthalmology, Volume 2018.
15. Yung-Hui Li, Nai-Ning Yeh, Shih-Jen Chen, Yu-Chien Chung. **"Computer-Assisted Diagnosis for Diabetic Retinopathy Based on Fundus Images Using Deep Convolutional Neural Network",** Hindawi, Mobile Information Systems, Volume 2019.
16. Jorge Calleja, Lourdes Tecuapetla, Ma. Auxilio Medina, Everardo Bárcenas, Argelia B. Urbina Nájera**. "LBP and Machine Learning for Diabetic Retinopathy Detection"** Intelligent Data Engineering and Automated Learning – IDEAL 2014, 2014, Volume 8669, ISBN: 978-3-319-10839-1
17. García G., Gallardo J., Mauricio A., López J., Del Carpio C. (2017) **"Detection of Diabetic Retinopathy Based on a Convolutional Neural Network Using Retinal Fundus Images.**" Artificial Neural Networks and Machine Learning – ICANN 2017. Springer.
18. S K, S., P, A. A, **"Machine Learning Ensemble Classifier for Early Prediction of Diabetic Retinopathy."** Journal of Medical System. Springer (2017).
19. Hemanth, D.J., Deperlioglu, O. & Kose, U. **"An enhanced diabetic retinopathy detection and classification approach using deep convolutional neural network."** Neural Computing & Applications, Springer (2020).
20. ftekhari, N., Pourreza, H., Masoudi, M. et al. **"Microaneurysm detection in fundus images using a two-step convolutional neural network."** BioMedical Engineering OnLine Springer Nature (2019).

MANAV RACHNA
Vidyanatariksha

Swami Vivekananda Library and Resource Centre
Manav Rachna University

SIMILARITY VERIFICATION CERTIFICATE

Title: Computer assisted early diagnosis of diabetic retinopathy using machine learning.

Researcher : Anju Mishra. Registration Number: 2K20-PFE-004

Supervisor: Dr. Mrinal Pandey. Department: Computer Science.

This is to certify that the above mentioned Short Synopsis /~~Thesis~~ was scanned for similarity index through Turnitin Software on 06/01/2021 with submission ID 1483545728 and the similarity index was found to be 07 %. The complete report running into 9 Pages, 2107 Word count with File Size 1234 KB is being forwarded to the Research Supervisor/DRC/DRB for review.

Swami Vivekananda Library and Resource Centre Faridabad * Manav Rachna University * 14/01/2021

Date: 14/01/2021

The complete report of the above Short Synopsis/~~Thesis~~ has been reviewed and the similarity index is below the accepted norms as per the University Grants Commission (Promotion of Academic Integrity and Prevention of Plagiarism in Higher Educational Institutions) Regulations 2018. The Short Synopsis/~~Thesis~~ may be considered for further processing.

Research Scholar 14/1/2021

Research Supervisor 14/1/2021

Short Synopsis Anju Mishra 6.01.2021

by Anju Mishra

ubmission date: 06-Jan-2021 09:31AM (UTC+0530)
ubmission ID: 1483545728
ile name: Anju_Mishra.docx (37.36K)
'ord count: 2107
haracter count: 12342

Short Synopsis Anju Mishra 6.01.2021

ORIGINALITY REPORT

Excluding matches less than 14 words

7%	4%	3%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	ijceronline.com Internet Source	2%
2	worldwidescience.org Internet Source	2%
3	Submitted to College of Engineering Trivandrum Student Paper	1%
4	V Sudha, C Karthikeyan. "Analysis of diabetic retinopathy using naive bayes classifier technique", International Journal of Engineering & Technology, 2018 Publication	1%

Exclude quotes On

Exclude bibliography On

Exclude matches < 14 words